6

THE OBERON BAY METEORITE

By M. J. Fitzgerald*

ABSTRACT: The Oberon Bay meteorite which was found on Wilsons Promontory in the early 1960's is described and an analysis presented. In the light of its composition and petrography the meteorite is classified as an LL6 chondrite.

INTRODUCTION

The Oberon Bay meteorite was found during a Christmas vacation period in the early 1960's; probably 1962-1963. The finder, Dr. V. A. Gostin, was walking through the sandhills near Oberon Bay on Wilsons Promontory when he came upon a sandblow among the dunes. The 180g meteorite was lying on the floor of the blow along with pieces of driftwood, rock fragments and general debris. Dr. Gostin picked it up, as it seemed unusual, and after sectioning it, suspected that it was a meteorite. He retained the specimen until 1972, when his identification was confirmed. He then donated the specimen to the University of Adelaide.

The meteorite has been tentatively identified as an LL chondrite (Hutchinson *et al.* 1977) and the aim of this note is to present a description and analysis of the meteorite and confirm this classification.

EXPERIMENTAL METHODS

X-ray fluorescence analysis was used for the determination of all elements except sodium for which a flame photometric method was employed. A modified version of the Norrish and Hutton (1969) technique for X.R.F. analysis was used. Olivine determinations were carried out both by an X-ray diffraction method using the technique of Yoder and Sahama (1957) involving the measurement of d_{130} spacings with zinc oxide as the internal standard and by electron microprobe. In the latter instance a Technisch Physiche Dienst microprobe fitted with a lithium drifted silicon detector was used and the data reduced using the method of Reed and Ware (1975). Full details of all methods are given in Fitzgerald (1979a.).

DESCRIPTION OF THE METEORITE

The shape of the meteorite is an oblate spheroid with a diameter of about 5 cm (Pl. 8). Prior to its discovery it had fractured in at least two places. These are now outlined on the relatively fresh surface by a 1-2 mm ridge of well rounded grains of quartz and other terrestrial detritus, of about 0.2 mm diameter, cemented together in a limonitic matrix. In places this 'conglomeratic crust' coats the meteorite over an area of many square millimetres and as it is very similar to the meteorite and does not readily separate from it, is not at first obvious. Because of this extra care was taken in preparing a sample for analysis. Separation along two of the fractures revealed a limonitic layer coating the joint surface. Several chondrules are visible penetrating the fusion crust. The overall spherical shape of the specimen is not interrupted by any feature indicative of flight orientation or resulting from ablationary sculpturing.

Numerous metal and sulfide grains, a few of which are surrounded by limonitic staining, can be seen on a cut surface. Areas of apparent complete replacement of metal or sulfide by limonite are also visible. Chondrules and rounded inclusions can be seen on this surface. The silicates vary from white through yellow to grey while the abundant disseminated sulfides give the matrix an overall black colour.

The grain size of the silicates is very variable. Although large, subrounded, fragments of silicate material are present, very few definite chondrules can be seen in thin section (Pl. 8, below). Some of the clasts consist of fragments of recognizable chondrule types, commonly partly rimmed by finer chondritic matrix but others consist solely of previously fragmented fine chondrule debris. Some of the coarser clasts have a granoblastic texture with numerous triple point junctions but others are composed of large fragments of very fine grained material set in a fine matrix. These appear to be remnants of porphyritic material in which the megacrysts and glassy mesostasis have been completely recrystallized. By contrast other porphyri-

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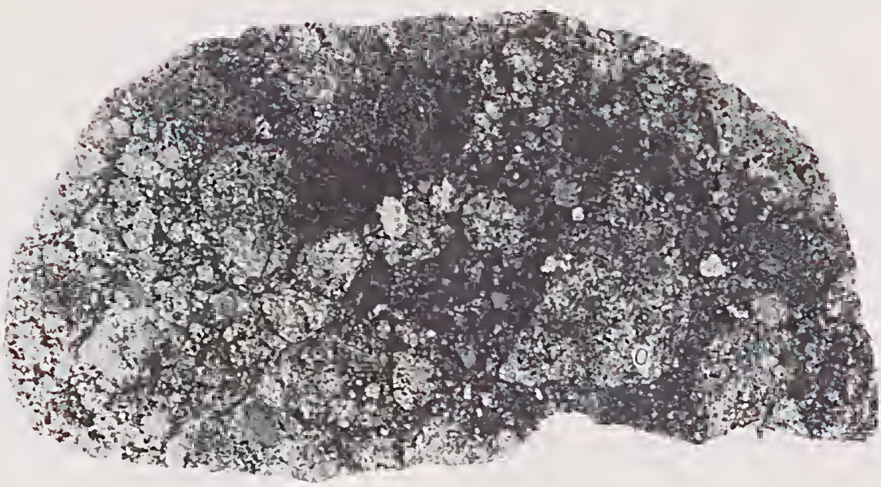

PLATE 8
(Above) Exterior view of Oberon Bay meteorite showing fractures outlined by limonite-cemented quartz grains (Scale bar 1 cm).
(Below) Thin section showing the fragmental nature of the Oberon Bay chondrite (Scale bar 5 mm).

tic clasts show minimal devitrification and recrystallization. Several of the clasts bear a superficial resemblance to C2 meteorites such as Adelaide (Fitzgerald & Jones 1977). The matrix content of the clasts is less than that of these carbonaceous chondrites however. Many of the clasts have sharp boundaries but others grade into the matrix which consists of very fine silicates set in an opaque base. Nickel-iron is generally far more abundant in this dark material and troilite is ubiquitous.

Many of the larger silicate grains exhibit varying degrees of shock in the form of undulose extinction and mosaic textures. Commonly the large orthopyroxene grains poikilitically enclose olivine chadacrysts and in some cases the grains are almost completely poikilitic with triple point boundaries between the olivine chadacrysts. Occasional grains of polysynthetically twinned clinopyroxene are also present.

BULK CHEMICAL COMPOSITION

The bulk composition is listed in Table 1 along with the results of a normative mineral calculation. The assumptions made in this modified form of the CIPW calculation are fully documented in Fitzgerald (1979a). Phosphorus is assigned to the mineral merrillite ($\beta-Ca_3(PO_4)_2$) as Dowty (1977) has shown this is the principal meteoritic phosphate species.

CLASSIFICATION

Values of the atomic ratios (expressed on a percentage basis) Ca/Mg (5.3), Fe/(Fe+Mg) (35), Al/Si (6.3) and Ca/Si (4.7) all lie within the limits used by Fitzgerald (1979a) to define the ordinary chondrites. Both the total iron content (18.4%) and the low value of 49 for the Fe/Si ratio are suggestive of an LL chondrite classification. The olivine composition as measured by X-ray diffraction is $Fa_{25.5}$ whereas the electron microprobe revealed the presence of a bimodal population of olivine grains, one having a mean composition of $Fa_{25.6}$ and the other $Fa_{17.7}$. A Coefficient of Variation of 0% for the first group showed this olivine to be homogeneous and well equilibrated whereas the value of 6% for the second group was indicative of a lack of equilibration. That the abundance of this second group of olivine grains is low is shown by the identity of the more iron-rich probe determinations and the diffraction results, the latter technique effectively measuring the average olivine composition. This olivine composition falls close to the accepted boundary between the L and LL chondrite groups and so could be interpreted as indicating either classification. The more iron-rich olivine occurs throughout the meteorite whereas the iron-poor variety is confined to the finer grained clasts which texturally resemble the carbonaceous chondrites mentioned above. The mean orthopyroxene composition of $Fs_{22.5}$ $Wo_{1.5}$, as determined by the microprobe, is consistent with either classification. Unlike the olivine, two groups of pyroxene compositions were not detected, but a C.V. of 3% indicates the range of measured values.

Several authors (e.g. Mason & Wiik 1964 and Fodor & Keil 1975a) have suggested that the LL chondrites are characterized by a scarcity of chondrules and a prominent brecciation. Fodor and Keil also described poikilitic fragments from five LL chondrites, generally finding olivine chadacrysts poikilitically enclosed in orthopyroxene oikocrysts. Wasson (1974) suggested that the LL chondrites are generally genomict breccias, that is, breccias consisting of material from the same chemical group but with different histories. He used this terminology to distinguished the LL chondrites from Wahl's (1952) polymict breccias in which the clasts are not necessarily related to the interstitial host or matrix. Wasson further suggested that the host and xenolith material of all the brecciated ordinary chondrites invariably belonged to the same chemical group, but recent work has shown that this is not always the case (e.g. Fodor & Keil 1975a,b, Fodor & Keil 1976, Fodor *et al* 1976). It appears that there are several true polymict brecciated chondrites in which the included clasts have bulk compositions significantly different from that of the host. Fodor and Keil (1975a) examined the LL3 chondrite Ngawi and concluded that even though it has an LL bulk composition it contains fragments having compositions corresponding to H, L and LL material. Plainview (1917) as described by Fodor and Keil (1976) consists of quite large light coloured fragments set in a dark matrix, and in addition, exotic lithic fragments are found in the dark matrix. A similar situation obtains in the case of Oberon Bay where the exotic lithic fragments appear to be confined to the fine matrix. However the situation is not as simple as in the case of Plainview, since some of the exotic clasts in Oberon Bay are of the same size, or larger, than the ordinary light coloured fragments.

Fodor and Keil (1975a) suggested that the poikilitic textures of the LL chondrites were produced during slow cooling following impact events. The brecciated and shocked nature of Oberon Bay attests to the role of impact events in its formation. It is also possible that the exotic fragments present in the meteorite are remnants of some of the projectiles which impacted the surface of the Oberon Bay parent body and further work on these clasts is planned.

In addition to the analytical results for Oberon Bay, Table 1 contains data for three other LL chondrites — Ngawi (LL3), Mossgiel (LL4) and Lake

TABLE 1
BULK CHEMICAL COMPOSITIONS AND NORMATIVE MINERALOGIES

	Oberon Bay[1]	Ngawi[2,4]	Mossgiel[3]	Lake Labyrinth[3]
Elemental abundances (weight percent)				
Fe	18.43	19.03	18.38	19.70
Mn	0.28	0.26	0.26	0.31
Ti	0.081	0.064	0.088	0.073
Ca	1.30	1.33	1.14	1.41
K	0.126	0.077	0.050	0.103
P	0.084	0.079	0.061	0.157
Si	19.23	18.88	18.83	19.37
Al	1.17	1.17	1.27	1.42
Mg	15.00	15.34	15.44	16.03
Ni	1.28	1.06	1.15	1.20
S	2.15	2.22	1.93	2.00
Cr	0.31	0.42	0.29	0.31
Na	0.71	0.73	0.55	0.86
Atomic ratios (percentages)				
Ca/Mg	5.3	5.3	4.5	5.3
Fe/(Fe+Mg)	35	35	34	35
Al/Si	6.3	6.5	7.0	7.6
Ca/Si	4.7	4.9	4.3	5.1
Fe/Si	49	51	49	51
Normative mineralogy (weight percent)				
Nickel-iron	10.5	8.6	9.4	9.3
Troilite	6.2	6.3	5.5	5.5
Merrillite	0.4	0.4	0.3	0.8
Ilmenite	0.3	0.2	0.3	0.2
Chromite	0.7	0.9	0.7	0.7
Feldspar	10.7	10.5	10.1	12.2
Diopside	5.5	6.2	3.4	4.7
Orthopyroxene	38.4	30.4	37.2	25.4
Olivine	27.4	36.6	33.1	41.2
Normative molar percent composition				
Ab } Feldspar	80	82	66	81
An } Feldspar	12	13	31	13
Fs Pyroxene	13	16	15	16
Fa Olivine	16	19	18	19

References: 1. This work 2. Ahrens et al. (1969) 3. Fitzgerald (1979b) 4. Mason and Wiik (1966)

Labyrinth (LL6). The brecciated nature of Oberon Bay obviously affects its bulk composition as this will simply be the average of the clasts and matrix which have been sampled and thus the marked resemblance between Oberon Bay and the other meteorites listed in Table 1 is significant.

Accordingly, on the basis of mineral and bulk compositions and textural features, Oberon Bay is classified as an LL chondrite. Despite the presence of occasional grains of polysynthetically twinned clinopyroxene, the absence of well developed feldspar, and the prominent nature of the clasts in this meteorite, the overall degree of recrystallization within the clasts is appropriate to petrologic type 6. Oberon Bay is accordingly classified as an LL6 chondrite and is thus another example of a polymict chondritic breccia.

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REFERENCES

AHRENS, L. H., VON MICHAELIS & FESQ, H. W., 1969. The composition of the stony meteorites (IV). Some analytical data on Orgueil, Nogoya, Ornans and Ngawi. *Earth Planet. Sci. Lett.* 6: 285-288.

DOWTY, E., 1977. Phosphate in Angra dos Reis: Structure and composition of the $Ca_3(PO_4)_2$ minerals. *Ibid.* 35: 347-351.

FITZGERALD M. J., 1979a. The chemistry and mineralogy of the meteorites of South Australia and adjacent regions. *Centre for Precambrian Research, University of Adelaide, Spec. Publn. No. 3*, 323 pp.

———, 1979b. The Mossgiel meteorite. *Trans. R. Soc. S. Aust.*, 103: 145-147.

FITZGERALD, M. J. & JONES, J. B., 1977. Adelaide and Bench Crater — members of a new subgroup of the carbonaceous chondrites. *Meteoritics* 12: 443-458.

FODOR, R. V. & KEIL, K., 1975a. Implications of poikilitic textures in LL-group chondrites. *Ibid.* 10: 325-339.

——— & ———, 1975b. Parent material for seemingly-exotic light-coloured lithic fragments in LL-group chondrites. *Ibid.* 10: 402.

——— & ———, 1976. Carbonaceous and non-carbonaceous lithic fragments in the Plainview, Texas, chondrite: origin and history. *Geochim. Cosmochim. Acta* 40: 177-190.

FODOR, R. V., KEIL, K., WILKENING, L. L., BOGARD, D. D. & GIBSON, E. K., 1976. Origin and history of a meteorite parent-body regolith breccia: carbonaceous and non-carbonaceous lithic fragments in the Abbott, New Mexico, chondrite. *New Mexico Geological Society Spec. Publn. No. 6. Tectonics and Mineral Resources of Southwestern New Mexico:* 206-218.

HUTCHISON, R., BEVAN, A. W. R. & HALL, J. M., 1977. Appendix to the Catalogue of Meteorites with special reference to those represented in the collection of the British Museum (Natural History). *Publication 789 of the British Museum.* Whitefriars Press, London, England, 297 pp.

MASON, B. & WIIK, H. B., 1964. The amphoterites and meteorites of similar composition. *Geochim. Cosmochim. Acta* 28: 533-538.

——— & ———, 1966. The composition of the Barratta, Carraweena, Kapoeta, Mooresfort, and Ngawi meteorites. *Amer. Museum Novitates* 2273: 1-25.

NORRISH, K. & HUTTON, J. T., 1969. An accurate X-ray spectrographic method for the analysis of a wide range of geologic samples. *Geochim. Cosmochim. Acta* 33: 431-453.

REED, S. J. B. & WARE, N. G., 1975. Quantitative electron microprobe analysis of silicates using energy-dispersive X-ray spectrometry. *J. Petrol.* 16: 499-519.

WAHL, W., 1952. The brecciated stony meteorites and meteorites containing foreign fragments. *Geochim. Cosmochim. Acta* 2: 91-117.

WASSON, J. T., 1974. *Meteorites – classification and properties.* Springer-Verlag, New York, U.S.A., 316pp.

YODER, H. S. & SAHAMA, T. G., 1957. Olivine X-ray determinative curve. *Amer. Mineral.* 42: 475-491.